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September 30, 2003

To: Scott Brown, U.S.E.P.A., Helena, MT.

From: Douglas J. Dollhopf, Pam Blicker and Dennis Neuman

Re: **Estimated Area In Helena Valley Where Total Soil Arsenic Concentrations Exceed 100 mg/kg and 176 mg/kg (Map 3).**

Objective

•Identify the area in the Helena Valley where there is less than a 2.5 % probability that total soil arsenic concentration is greater than either 100 mg/kg or 176 mg/kg.

Results are exhibited on attached Map 3. Support calculations are presented below.

Support Documents Used

During the remedial investigation, 157 soil samples were collected (0-4 inch depth)across the entire Helena Valley and geostatistics, variograms, and kriged maps were used to delineate the distribution of total soil arsenic (CH2M Hill 1987a, pages 3.52-3.58). Subsequently, yard sampling in East Helena resulted in collection of hundreds of soil samples (0-1 inch depth) and a sector statistics method was used to identify areas where 1000 mg/kg total lead was exceeded, which was the criterion for yard removal (Hydrometrics, Inc. 1995). An XRF laboratory method was used to analyze soil samples, so both total arsenic and total cadmium concentrations were reported in addition to the total lead.

Helena Valley Area Where Total Soil Arsenic Concentration Is Greater Than 176 mg/kg

Using geostatistics, a semivariogram and associated kriged maps (Figures 3.7 and 3.8, CH2M Hill 1987a) were prepared that depicted soil arsenic across the Helena Valley for the 0-4 inch depth increment. The following calculation was developed to determine the area within the Helena Valley where there is less than a 2.5 % probability that total soil arsenic concentration is greater than 176 mg/kg. Total soil arsenic values used for this analysis are presented in Appendix Table 1.

•On Figure 3.8, the area encompassed by the 2.245 ($\log_{10}$) isopleth line is composed

almost entirely of soils (0-4 inch depth) having greater than 176 mg/kg total arsenic. Total soil arsenic concentrations greater than 176 mg/kg will be encountered outside the 2.245 ($\log_{10}$) isopleth line, but there is less than a 2.5 % probability of locating such soil concentrations outside the 2.17 ($\log_{10}$) isopleth line on Figure 3.8. The 2.17 ($\log_{10}$) isopleth line equates to a total soil arsenic concentration of 148 mg/kg. The calculation in support of this finding follows.

•One tailed t-value @ n = 157 @ 97.5 % confidence = 1.96
As shown on Figure 3.7, a standard error of 0.04 is appropriate to use for the soil area containing greater than 176 mg/kg As.

$2.17 + (0.04)(1.96) = 2.245$
$10^{2.245} = 176$ mg/kg As

In Figure 3.8, the isopleth line labeled 2.17 ($\log_{10}$) encompasses an area of 274 acres, approximately 0.8 by 0.7 miles, beyond which there is less than a 2.5 % probability of locating a soil concentration greater than 176 mg/kg As. This area is located immediately south of the city of East Helena, largely in the vicinity of the ASARCO smelter complex and nearby areas. However, this analysis indicates that as many as 2.5 % of soil samples collected outside this area may contain total soil arsenic greater than 176 mg/kg. Since the city of East Helena is immediately north of the area encompassed by the 2.17 ($\log_{10}$) isopleth line, it is probable that as many as 2.5 % of soil samples collected in East Helena would exceed the 176 mg/kg total arsenic criterion. Since the sampling increment for East Helena yards was 0-1 inch the sample number exceeding 176 mg/kg arsenic may be different than that indicated by this statistical measure based on the 0-4 inch depth increment.

A Note Of Caution

This kriged map (CH2M Hill 1987a) can be used to provide guidance on soil arsenic concentrations across the Helena Valley and to aid in design of field sampling efforts. Although statistical levels of confidence can be calculated for arsenic concentration lines shown on Figure 3.8, caution should be exercised when making an interpretation. This map was developed using a predictive model based on 157 soil samples across the Helena Valley. Because cleanup decisions for individual properties need to be based on exact boundaries of soil arsenic concentrations, additional soil sampling and associated laboratory analysis must be done to define these boundaries with higher levels of confidence.

Comparison Between Sector Closure Statistics And Results Shown On The Kriged Map

Sector statistics were calculated using total soil lead values, but total soil arsenic values were also reported by the analytical laboratory (Hydrometrics 1995, Appendix 1). Using these data from

1995, total soil arsenic values were reported for 296 residential properties in East Helena. For each residence, 2 to 30 soil samples were collected from the 0-1 inch depth increment and each was analyzed for total soil arsenic. A total of 1460 soil samples were collected for analysis at these 296 residences. This sample total (1460) includes those collected from gardens and irrigation ditches, but does not include duplicate samples collected for purposes of quality control. Given these 1460 samples, 64 exceeded 176 mg/kg. This means 4.4 % of thee samples collected from the 0-1 inch depth increment at residential properties exceeded 176 mg/kg. Therefore, the kriged map (CH2M Hill 1987a, pages 3.52-3.58) and residential soil sampling results (Hydrometrics 1995, Appendix 1) indicate a similar result regarding where Helena Valley soils exceed 176 mg/kg total soil arsenic.

Given the 296 residential properties sampled (Hydrometrics 1995, Appendix 1), 9.1 % (27) had one or more samples where the total soil arsenic exceeded 176 mg/kg. However, when the mathematical mean was calculated across the samples collected within a yard, only two residential properties exceeded 176 mg/kg total soil arsenic. Personal communication with the U.S. Environmental Protection Agency, Helena (S. Brown, September 17, 2003) indicated both of these properties already underwent yard removal which was triggered by total soil lead that exceeded the 1000 mg/kg criterion. .

Helena Valley Area Where Total Soil Arsenic Concentration Is Greater Than 100 mg/kg

Review of scientific literature indicated growth of many plant species is impaired when the total soil arsenic concentration exceeds 100 mg/kg (CH2M Hill 1987b). The following calculation was developed to determine the area within the Helena Valley where there is less than a 2.5 % probability that total soil arsenic concentration is greater than 100 mg/kg.

- On Figure 3.8 (CH2M Hill 1987a), the area encompassed by the 2.0 ($\log_{10}$) isopleth line is composed almost entirely of soils (0-4 inch depth) having greater than 100 mg/kg total arsenic. Total soil arsenic concentrations greater than 100 mg/kg will be encountered outside the 2.0 ($\log_{10}$) isopleth line, but there is less than a 2.5 % probability of locating such soil concentrations outside the 1.922 ($\log_{10}$) isopleth line on Figure 3.8. The 1.922 ($\log_{10}$) isopleth line equates to a total soil arsenic concentration of 84 mg/kg. The calculation in support of this finding follows.

- One tailed t-value @ n = 157 @ 97.5 % confidence = 1.96
  As shown on Figure 3.7 (CH2M Hill 1987a), a standard error of 0.04 is appropriate to use for the soil area containing greater than 100 mg/kg As.
  $1.922 + (0.04)(1.96) = 2.0$
  $10^{2.0} = 100$ mg/kg As

In Figure 3.8 (CH2M Hill 1987a), the isopleth line labeled 1.922 ($\log_{10}$) encompasses an area of 711 acres, approximately 1.3 by 1.0 miles, beyond which there is less than a 2.5 % probability of

locating a soil concentration greater than 100 mg/kg As. This area encompasses the smelter complex and nearby areas to the south and east.

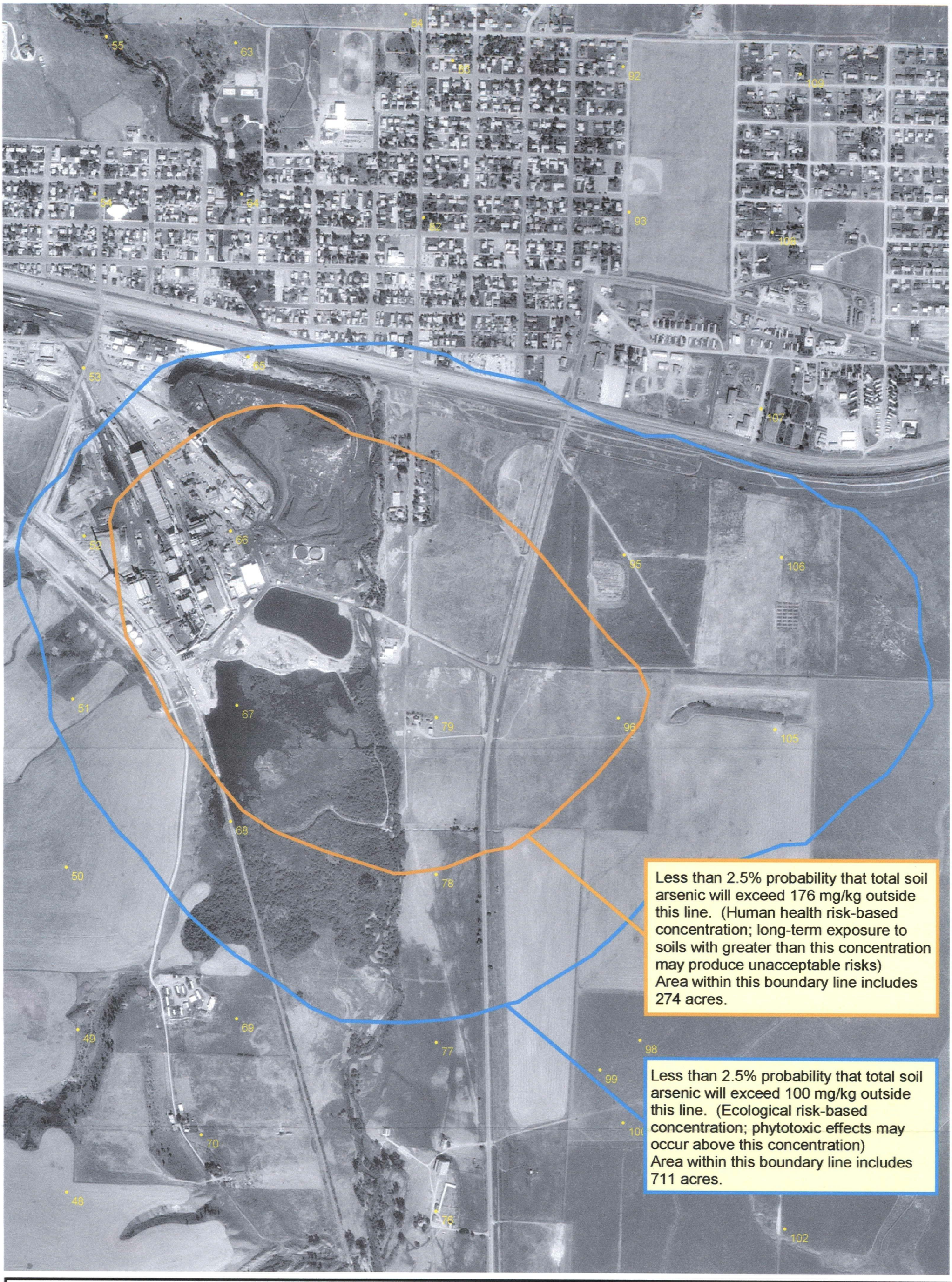
References Cited

CH2M Hill. 1987a. Remedial investigation of soils, vegetation and livestock, East Helena site (ASARCO), MT. Prepared for Environmental Protection Agency, Helena, MT.

CH2M Hill. 1987b. Assessment of the toxicity of arsenic, cadmium, lead and zinc in soil, plants, and livestock in the Helena Valley of Montana. East Helena Site (ASARCO). EPA Work Assignment No. 68-8L30.0. Prepared for U.S. EPA, Helena, MT. 206 p.

Hydrometrics, Inc. 1995. East Helena residential soils sector sampling summary. Prepared for ASARCO, Inc, Helena, MT.

See Appx. 1 of Oct. 9 memo.



MAP 3. ESTIMATED DISTRIBUTION OF TOTAL SOIL ARSENIC FOR THE 0-4 INCH DEPTH INCREMENT IN THE HELENA VALLEY, MONTANA

○ Remedial Investigation Sample Locations (CH2M Hill 1987)

Base Map Photo 1997

0.25 0 0.25 0.5 Miles

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